Hawaii Electric Light Company, Inc. • PO Box 1027 • Hilo, HI 96721-1027

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PUBLIC UTILITIES COMMISSION

Jay M. Ignacio, P.E.
President

May 1, 2013

The Honorable Chair and Members of
the Hawaii Public Utilities Commission
Kekuanaoa Building
465 S. King Street, 1st Floor
Honolulu, Hawaii 96813

Dear Commissioners:

Subject: Hawaii Electric Light Company, Inc.
March 2013 Kaumana-Pohoiki 6500 Line Events

Hawaii Electric Light Company, Inc. ("HELCO") respectfully submits the attached report that describes the interruptions of the Kaumana-Pohoiki 6500 69kV transmission line from March 10, 2013 to March 25, 2013, and the findings and follow-up actions taken by HELCO. (See Exhibit 1.)

Sincerely,

Attachments

c: Division of Consumer Advocacy (with Attachments)

March 2013 Kaumana-Pohoiki 6500 Line Events

Prepared by HELCO Distribution Department
4/30/2013

Purpose

Describe the interruptions of the Kaumana-Pohoiki 6500 69kV transmission line from March 10, 2013 to March 25, 2013, and the findings and follow-up actions taken HELCO.

Executive Summary

Between March 10, 2013 and March 25, 2013, HELCO's Kaumana to Pohoiki transmission line (6500 line) experienced a series of six (6) outages. The most significant event occurred on March 13, 2013, when an outage on the 6500 line resulted in a simultaneous outage of HELCO's Pohoiki to Puna (8700 line), which in turn resulted in the Puna Geothermal Venture (PGV) generating plant being separated from HELCO's grid, and necessitated an emergency shutdown of PGV's operation. This outage also affected 20,095 customers for periods from six seconds to as long as fifteen minutes, and was reported in the local news media.

After performing line inspections, reviewing data from protective relaying and correlating weather information to the time of the faults, HELCO has concluded that the external cause of the 6500 transmission line outages was trees and branches momentarily brushing the transmission line. HELCO has since performed significant trimming along the 6500 line, well beyond normal clearances to reduce the likelihood of reoccurrence. HELCO also discovered a subtle flaw in the protective relay settings for the 8700 line that caused the March 13, 2013 outage of the 8700 line. The relay settings for the 8700 line were corrected and the settings for other transmission lines were checked.

Listed below is a summary of the activities and follow-up actions that HELCO performed subsequent to the series of recent line outages.

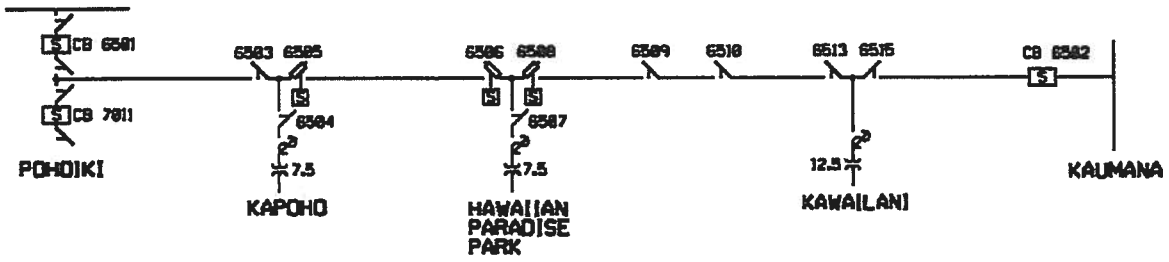
- Performed visual ground inspection of the 6500 line immediately following the individual events.
- Performed analysis on HELCO substation equipment to determine the cause of the 8700 line outage that resulted in the PGV steam release issue.
- Made adjustments to HELCO substation equipment to address faulty equipment settings.
- Performed visual aerial (helicopter) inspection of the 6500 line and equipment.
- Performed aerial (helicopter) infra-red camera inspection of the 6500 line and equipment.
- Performed bulldozing and extensive tree removal and tree trimming to the right-of-way along the 6500 line.
- Using bucket trucks, performed top to bottom, up close visual inspection on all poles in the areas where the faults occurred.
- Adjusted motor operated disconnect switches on the 6500 line to insure that all parts are within the manufacturer's specifications.

Background

The 6500 line is one of two 69 kV transmission lines interconnecting the PGV generating plant to the HELCO grid. It is approximately 29 miles long, and runs from the Kaumana Substation in the upper Hilo area to the Pohoiki Substation in lower Puna. (See Attachment 1 – Partial Island Transmission Map.) The 6500 line is not solely a transmission line but also operates as a sub-transmission line that serves

load along its route. There are three distribution substations tapped off of the 6500 line – Kawailani substation in the Waiakea area of Hilo, Hawaiian Paradise Park (HPP) substation in the HPP subdivision area of lower Puna, and Kapoho substation down in Kapoho area of lower Puna. A total of 9,520 customers are served off of these three substations. When an outage occurs on the 6500 line, power interruptions also occur to the customers served by the substations tapped to the line.

Single Line Diagram of the 6500 Line



Special devices called protective relays are installed at the switching stations at the end of the line to monitor the voltages and currents of the line. When an abnormal condition occurs on the transmission line like a tree branch brushing the line, very high currents (fault currents) result. The protective relays detect these abnormal conditions and sends commands to the circuit breakers at the switching stations to disconnect the transmission line from the rest of the system. Failure to remove these abnormal conditions or faults from the system very quickly could result in a total system collapse. HELCO's transmission protection is designed to remove faults from the rest of the system in a fraction of a second.

HELCO utilizes protective relays that are able to determine the approximate location of the fault or problem. HELCO's experience with the fault locating capability of these protective relays has been good and HELCO has found the relays to be relatively accurate in pinpointing problems. In most instances, HELCO has been able to correlate the fault locating information from the protective relays to the actual cause of the fault out in the field.

Throughout the electric industry, utilities have found that most faults or problems on transmission lines are temporary in nature and are self-correcting. Examples of these kinds of faults are a lightning strike or a tree branch brushing the line. In the case of a lightning strike, the lightning strike occurs to cause an electric fault but typically no permanent damage to the line occurs. The transmission line is taken out of service by the protective devices and after waiting a short period after the lightning strike, the transmission line can be restored. In the electric industry, this practice is called automatic reclosing.

For HELCO, automatic reclosing is applied on its transmission system with a 6 second delay. In instances where HELCO utilizes a transmission line to also serve customer load, as in the case with the 6500 line, customers experience a short 6 second power interruption when the transmission line experiences a temporary fault or problem and a successful automatic reclose occurs. Five of the six power interruptions that customers experienced on the 6500 line from March 10 – 25, 2013 were for the short duration of 6 seconds because of successful automatic reclosing in those instances.

Event 1 and 2 – Sunday 3/10/13 (TC# 1301511)
At 12:39:14, circuit breakers ("CB") 6501/7011 at the Pohoiki substation and CB 6502 at the Kaumana substation opened and reclosed automatically at 12:39:20 due to a fault on the 6500 transmission line. Power was interrupted for approximately 6 seconds to 9,520 customers served by the Kawailani, Hawaiian Paradise Park (HPP) and Kapoho substations. These substations serve HELCO customers in the Ainaola subdivision, upper Waiakea Uka, Waiakea, Hawaiian Paradise Park subdivision, sections of Pahoa, Leilani Estates subdivision, Nanawale subdivision, Kapoho Vacationland and Beachlots.

At 14:10:04, CBs 6501/7011 at the Pohoiki substation and CB 6502 at the Kaumana substation opened again and reclosed automatically at 14:10:10 due to another fault on the 6500 transmission line. Power was interrupted for approximately 6 seconds to the same 9,520 customers. Fault distances were obtained and were estimated to be located 15 miles from where the first fault occurred.

The Big Island had windy weather, although not strong enough to have a wind advisory issued by the National Weather Service. HELCO was experiencing numerous small wind related outages on Sunday, 3/10/13, that needed to be addressed by the day shift Trouble/Inspector ("T/I") and the evening shift T/I (called in early before 3 pm). As a result, inspection of the 6500 line was held off until the next day, Monday, 3/11/13.

On Monday, 3/11/13, the two T/I's visually inspected the 6500 line in spots close to the fault locations provided by the relays and found the line to be clear. Both of these spots are not easily accessible since they are not located near roads and also have trees along the route. One T/I visually inspected the area from pole P3, near the Puna substation, to pole P31, near Puna Rock on old Railroad Ave (event 2 fault location). The other T/I visually inspected from poles P214 to P222 behind Nanawale Estates (event 1 fault location). This required walking in areas because there was no driving access. The T/I also visually inspected the area when it was dark to see if there was any tracking (i.e., visible arcing) on the insulators. No problems were found. (See Attachment 2 – Pole Line Map of Affected Areas.)

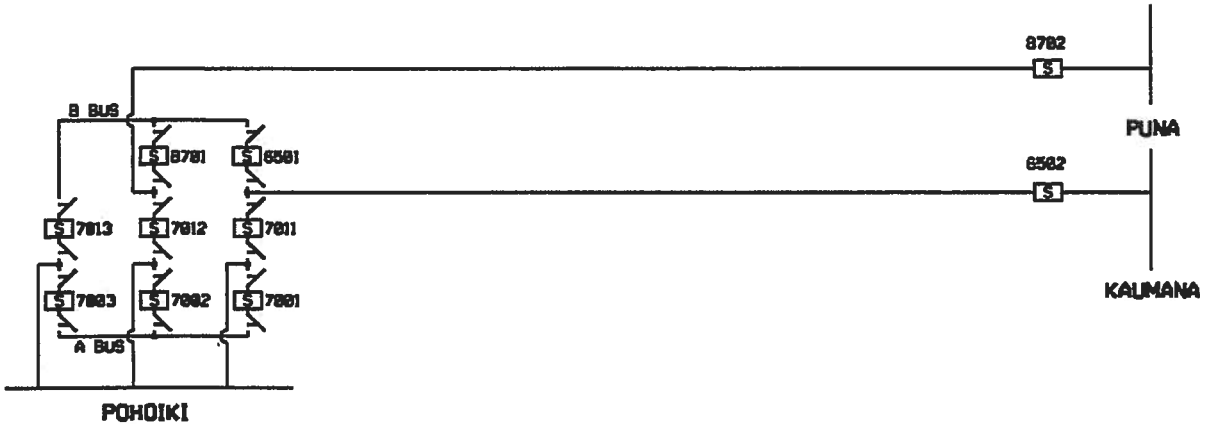
Event 3 – Monday 3/11/13 (TC# 1301539)
At 17:27:07, CBs 6501/7011 at the Pohoiki substation and CB 6502 at the Kaumana substation opened again and reclosed automatically at 17:27:13 due to a fault on the transmission line. Power was interrupted for approximately 6 seconds to the same 9,520 customers. Fault distances that were obtained were similar to the event 2 fault location.

The evening T/I traced the area from pole P3, near the Puna substation, to pole P31, near Puna Rock, again that night in the dark to look for tracking (i.e., visible arcing). The line was found to be clear and no tracking was observed.

On Tuesday, 3/12/13, the helicopter was used to inspect the entire 6500 line from the air. This inspection consisted of a visual inspection to check for any trees near the line and any physical damage or deterioration to the line, poles and equipment. There were no obvious problems found along the line. The line appeared to be clear.

Event 4 – Wednesday 3/13/13 (TC# 1301605)
At 15:53:48, CBs 6501/7011 at the Pohoiki substation and CB 6502 at the Kaumana substation opened again, along with the Puna substation CB 8702 due to a fault on the 6500 transmission line. This disconnected PGV's 38 megawatts of generation from the HELCO system and caused 20 circuits around the island to open automatically due to the under-frequency load shedding scheme (blocks 1 and 5). This shutdown also resulted in a controlled release of scrubbed steam from the PGV facility and triggered a response from Hawaii County Civil Defense and the Hawaii County Fire Department due to concerns from the citizens in areas close to the PGV facility. A total of 20,095 customers lost power for various amounts of time up to 15 minutes long. This event also caused PGV to vent abated steam into the atmosphere to relieve pressure on the system.

Single Line Diagram of 6500 and 8700 line



Restoration of Event 4 – 3/13/13
The same 9,520 customers on the 6500 line were restored in 6 seconds when Kaumana CB 6502 reclosed automatically. The system operator immediately started several fast-start diesels islandwide to add generation to the system. The system operator opened Kawailani CB 12 at 15:56:30 thinking the 6500 line was de-energized (i.e., procedures call for load to be stripped before restoring the transmission line). After realizing that the 6500 line was energized from Kaumana, the system operator quickly re-closed Kawailani CB 12 at 15:56:56. The transmission line was restored soon after when the system operator closed Pohoiki CB 6501 at 15:57:18, energizing the Pohoiki substation and the 8700 line, and allowing Puna CB 8702 to automatically reclose at 15:57:20. Distribution circuits island-wide were restored over the next 15 minutes. In addition, the Ainaloa substation circuits were found to have opened due to under-frequency on the PGV side of the disconnection because they were islanded from the system.

The under-frequency circuits that were affected (does not include Kawailani substation – 2,729 customers – that was only interrupted with the 6500 line) include the following:

UFLS Block	Circuit	Outage Time	Restore Time	Customers
Block 1, 58.8 Hz, 10 cyc	Waikoloa 11	15:53:48	16:00:50	1814
	Waikoloa 12	15:53:48	16:01:10	820
	Kuakini 13	15:53:48	15:58:20	277
	Kuakini 14	15:53:48	15:58:42	1292
	Waika 11	15:53:50	16:01:38	28
	Waika 12	15:53:50	16:02:16	483
	Palani 11	15:53:50	15:59:10	137
	Palani 12	15:53:50	15:59:46	1164
	Kaloko 13	15:53:48	16:07:56	114
	Kaloko 14	15:53:48	16:00:26	89
	Keahuolu 11	15:53:48	16:01:52	130
	Keahuolu 12	15:53:48	16:02:02	592
Block 2, 58.5 Hz, 10 cyc *(Islanded with PGV)*	Ainaloa 11	15:53:58	16:08:28	1765
	Ainaloa 12	15:53:58	16:08:48	881
Block 5, 59.3 Hz, 20 sec	Kapoho 11	15:54:12	16:02:56	378
	Kapoho 12	15:54:12	16:03:46	781
	Kapoho 13	15:54:12	16:04:20	1371
	Capt Cook 12	15:54:14	16:02:36	2734
	HPP 11	15:54:12	16:03:06	1418
	HPP 12	15:54:12	16:04:06	1098

Investigation after Event 4 – 3/13/13

The cause of the Puna CB 8702 opening for a fault on the 6500 line was investigated immediately after the event and resolved the next morning on 3/14/13. The SEL-421 relay for the Pohoiki 8701/7012 end of the 8700 line had incorrect logic in the settings that sent a permissive signal[1] to the Puna 8702 relay when only one of the two breakers at Pohoiki was open. (Pohoiki 8701 was open and isolated for crews to perform maintenance.) Normally, both CB 8701 and CB 7012 must be open in order for a permissive signal to be sent. In this instance, the permissive signal was sent even though both CB8701 and CB7012 were not open. Because the permissive signal had been received, Puna CB 8702 was allowed to open when it sensed a fault, even though the fault was not on the 8700 line. This mis-operation caused PGV to be disconnected from the system when both the 6500 line and the 8700 line opened.[2]

The search for the problem on the 6500 line intensified that evening. The fault distance for event 4 placed the problem near Nanawale Estates, similar to event 1. The T/I traced the line Wednesday night from poles P200 to P192, and from poles P200 to P207. The line appeared to be clear and no problem was found. (See Attachment 2 – Pole Line Map of Affected Areas.)

On Thursday, 3/14/13, the helicopter was used again to inspect the 6500 line from the air both visually and with the use of an infra-red detecting camera that can detect loose connections and other conditions not visible to the naked eye . No trees were found on the line and no equipment problems

[1] There is a communication system that sends data between substations that allows or prevents equipment operation based on specific conditions detected by the equipment. A Permissive Signal is a signal or message that is sent from one end of the transmission line to the other end to instruct the receiving equipment that it has permission to operate with more sensitive fault detection settings.

[2] The PGV plant is connected to the rest of the HELCO system through the 6500 and 8700 69kV transmission lines.

were found. Some trees were noted below the line between poles P37 and P38, and a canopy of trees over the lines between poles P35 and P37. Behind Nanawale Estates, from poles P195 to P220, trees were trimmed before but now there were some overhanging branches.

On Thursday night, 3/14/13, three linemen drove and walked several sections of line to perform a night inspection looking for trees or tracking. No problems were found.

- Poles P3 to P41 – Puna Substation to Shower Drive, HPP.
- Poles P41 to P53 – Went street-to-street where lines are behind the homes
- Poles P53 to P151 – Performed driving inspection
- Poles P151 to P189 – No driving access, not inspected
- Poles P190 to P201 – Performed drive/walking inspection
- Poles P201 to P205 – Performed walking inspection. Thick vegetation.
- Poles P210 to P224 – From private property distant from the line, checked for tracking

On Friday, 3/15/13, the Kapoho substation was offloaded and tested (SWO #310-005). There was a fault on the Kapoho 12 circuit on 3/10/13 at 12:23:13 due to an albizia tree on the Kapoho 12 12 kV line, approximately half an hour before the first 6500 line fault. To rule out possible damage to the equipment in the Kapoho substation, the transformers, lightning arresters, reclosers and cables were tested. On Saturday, 3/16/13, all of the 12kV lightning arresters were replaced because a few showed pending failure during previous infra-red inspections. No problem was found in the substation and all equipment tested "good".

On Saturday, 3/16/13, tree trimmers worked in the area of the 6500 line between pole P3 near the Puna substation and pole P41 near Shower Drive, HPP (event 2 and 3 fault locations).

On Monday, 3/18/13, line crews with buckets inspected pole-by-pole from pole P3 to pole P41. SWO #6500-118 opened the line between SW 6508 and SW 6509. The crews found some burnt branches (not albizia) on the ground between poles P37 and P38, which could possibly have been the cause of a fault. Other than that, the insulators looked good.

On Monday, 3/18/13, HELCO started bulldozing for roads to inaccessible areas by Nanawale Estates (poles P192-P209). This allowed the bucket trucks to enter and do closer inspections. Bulldozing continued on the other side of Nanawale Estates (poles P214 to P237) on Thursday, 3/21/13, and was completed on Wednesday, 3/27/13. HELCO's plans are to maintain these access roads with herbicide.

Event 5 – Friday, 3/22/13 (TC# 1301773)

HELCO crews planned to do an up close visual inspection of the 6500 line from pole 192 to pole 209. To safely accomplish the work the line needed to be deenergized. HELCO crews began the planned switching (order SWO #6500-119) necessary to deenergize the 6500 line and during the switching at 09:16:59, CB's 6501/7011 at the Pohoiki substation and CB 6502 at the Kaumana substation opened again and reclosed automatically at 09:17:05. Power was interrupted for approximately 6 seconds to the same 9,520 customers. When motor-operated switch (MOS) 6506 opened, the slight imbalance of phases created enough ground current for circuit breakers on both ends of the transmission line to operate. No problem was found with any of the insulators.

Event 6 – Monday, 3/25/13 (TC# 1301803)
On Monday, HELCO crews planned to address the issue from the previous week involving MOS 6506. Again to safely accomplish the work, the line needed to be de-energized. HELCO crews utilized MOS 6508 to isolate MOS 6506. At 11:08:01, CB's 6501/7011 at the Pohoiki substation and CB 6502 at the Kaumana substation opened again and reclosed automatically at 11:08:07 during planned switching order SWO #6500-120. Power was interrupted for approximately 6 seconds to 5,579 customers. (The customer count was less than before because customers on HPP substation were transferred to another substation for this switching order.) The same issue experienced with MOS 6506 the previous day also occurred when MOS 6508 opened, that is, the slight imbalance of phases created enough ground current for relays on both ends of the transmission line to operate. This switching order was executed to de-energize the area around MOS 6506 and MOS 6508 near HPP substation to allow the crews to safely inspect and adjust the MOS switch. No problem was found with either of the MOS switches.

As a result of the last two events, switching of the 6500 line was stopped to avoid further interruptions. Inspection from the bucket trucks from pole P214 to pole P237 continued during the week of 4/1-4/5, but were not as close to the lines as when the lines were de-energized due to safety reasons.

In addition, relay settings for the transmission lines are being looked at by the Hawaiian Electric Protection Group to see if the sensitivity of the ground settings can be reduced to allow mid-line switching.

(See Attachment 4 for additional information regarding the six interruptions and fault locations.)

Additional Event – Tuesday, 4/9/13 (TC# 1302110)
At 09:34:08, CBs 6501/7011 at the Pohoiki substation and CB 6502 at the Kaumana substation opened again and reclosed automatically at 09:34:12 due to a HELCO contractor dropping a tree on the 69 kV transmission line. The contractor was trimming trees between pole P222 and pole P223 near Nanawale Estates. Power was interrupted for approximately 4 seconds to the same 9,520 customers. The contractor's safety rules and procedures are being reviewed.

Tree Trimming Activities on the 6500 Line
Extensive tree trimming was done during the week of 3/18-3/22 from pole P192 to pole P205. Five (5) trimming crews addressed a total of 682 albizia trees. In total, 575 trees were removed and 107 trees were trimmed.

Comprehensive tree trimming continued during the week of 3/25-3/29 from poles P205 to P209 and from poles P214 to P230. (Attachment 3 contains pictures taken on 3/26/13 of the 6500 line.) To-date, over 2,700 trees have been either cut down or trimmed.

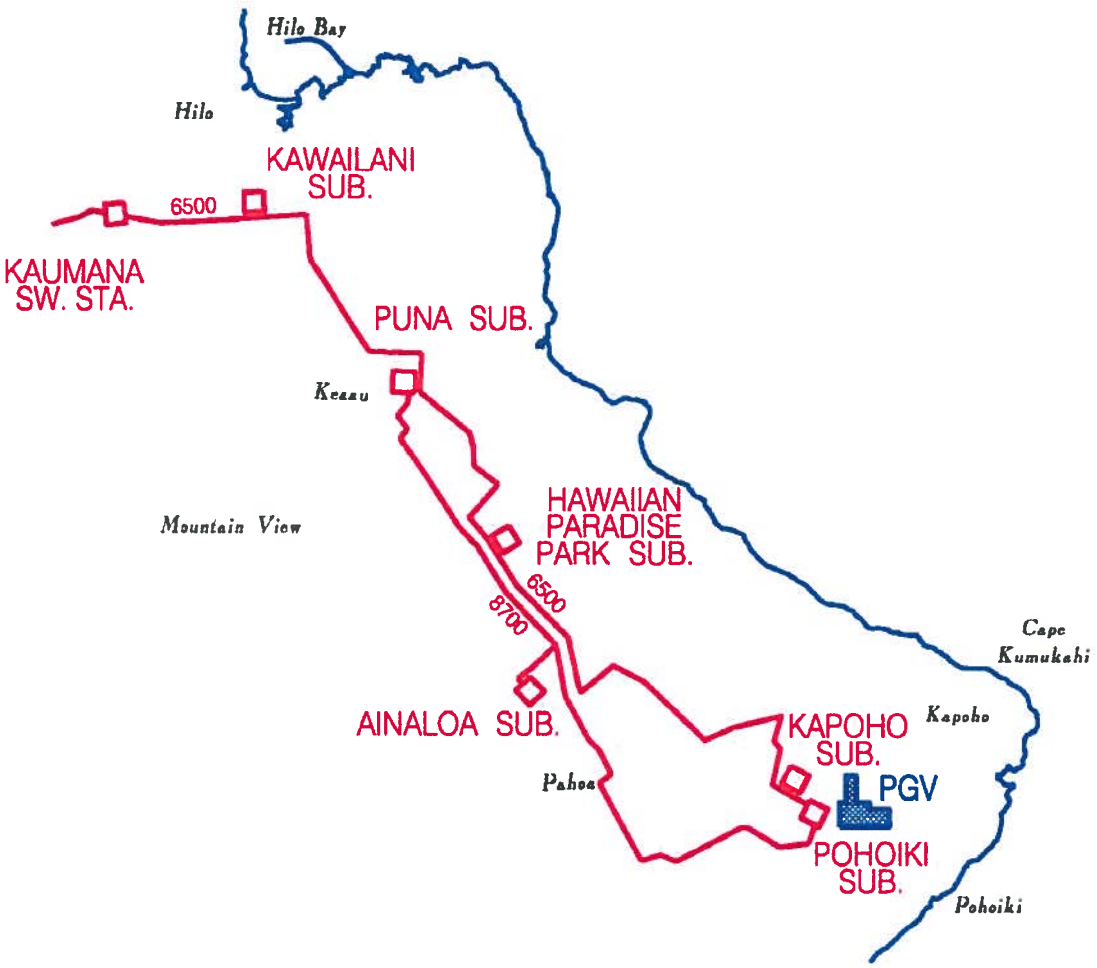
Note that the last comprehensive tree trimming in this area was in 2011 when the canopy of albizia was trimmed back. This 2013 trimming effort is getting even more clearance than in 2011. Later in 2013, a crane will be used to clear the higher branches of the canopy areas.

Conclusion

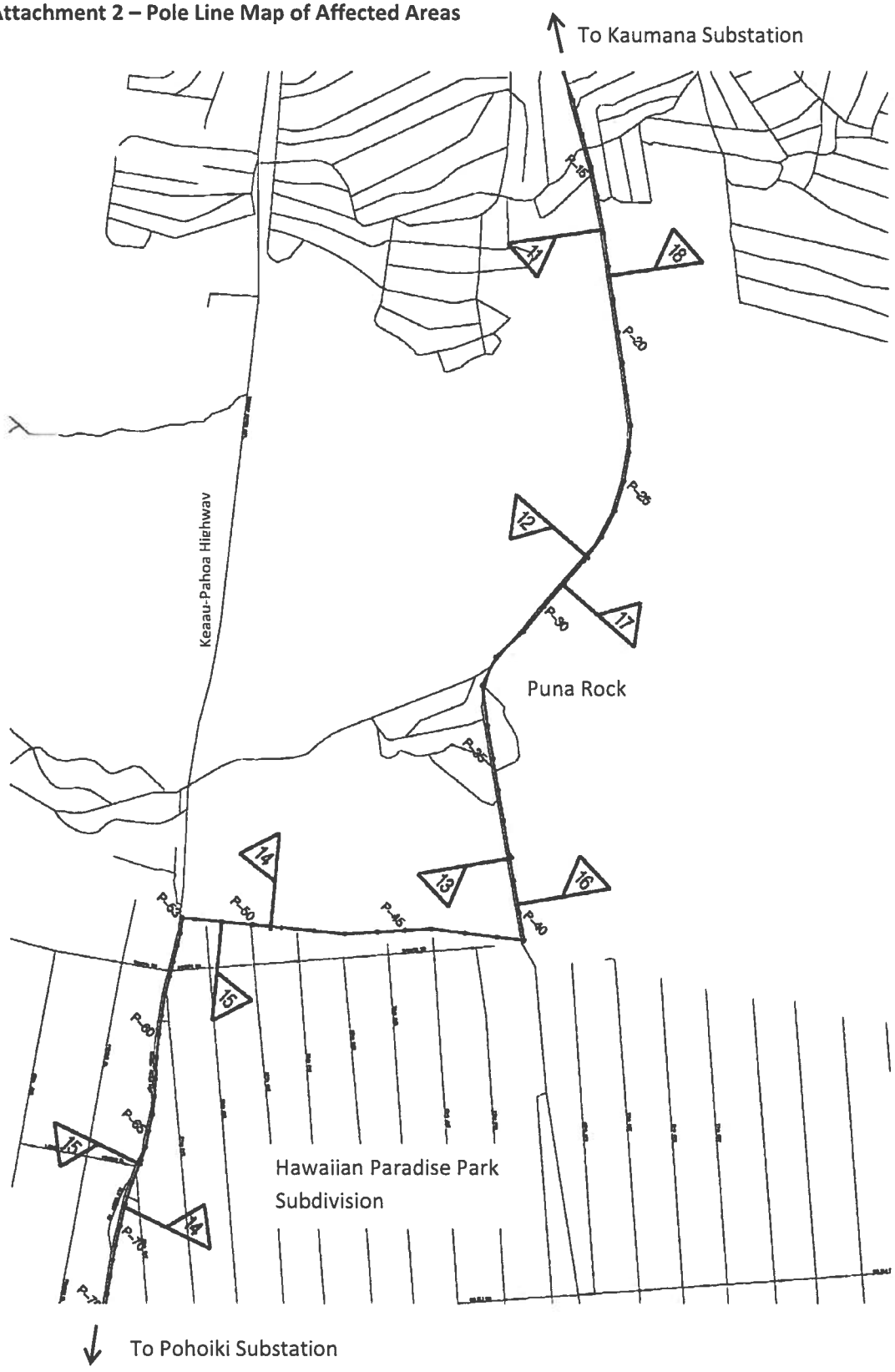
6500 line. The inspection plan related to events 1 thru 4 is completed. Extensive bulldozing, tree trimming and tree removal along the line have been done as noted in the report above and there have not been any further events on the 6500 transmission line. Due to heavy vegetation in the areas that correlated with the fault distances detected by the system, as well as the windy weather conditions at the time, it is likely that the initial outages were a result of trees/branches momentarily contacting the energized circuit. Possible evidence supporting this was found, but was not conclusive, which is why the inspection of the line is continuing. Events 5 and 6 were caused when Motor Operated Switches (MOS) were operated during switching. Solutions to prevent a reoccurrence are being evaluated and some options may include adjusting the transmission relay settings, curtailing PGV's output or offloading Kawailani or Kapoho customers to allow the circuit breakers to break the loop.

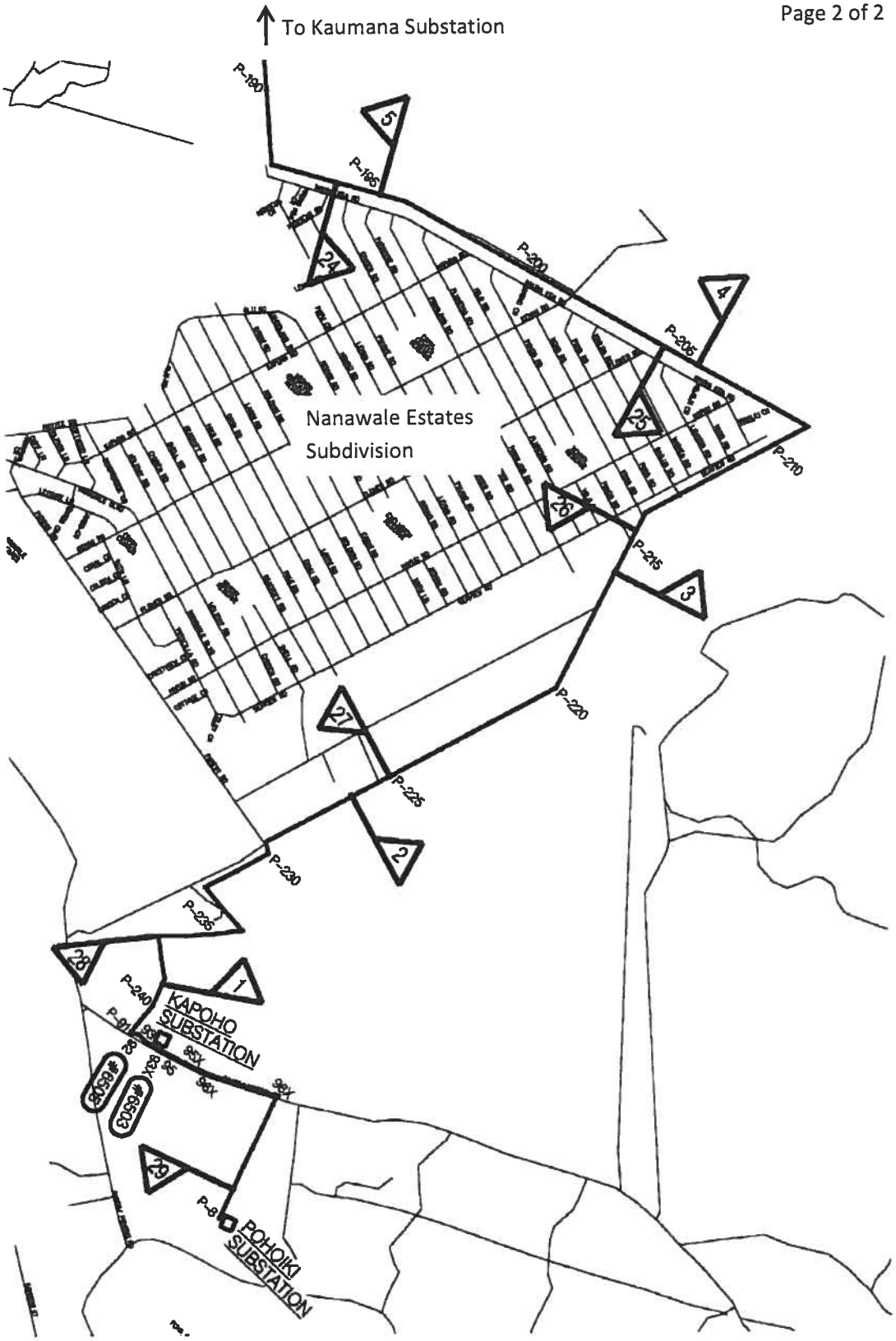
8700 Line (Event 4). The outage of the 8700 line was traced to incorrect logic in the settings in a relay at the Pohoiki substation. The settings have been corrected and this issue is resolved. There have been two subsequent outages on the 6500 line and they did not result in a repeat of Event 4.

Attachment 1 – Partial Island Transmission Map



Attachment 2 – Pole Line Map of Affected Areas




To Kaumana Substation
Nanawale Estates
Subdivision
KAPOHO
SUBSTATION
POHOIKI
SUBSTATION

Attachment 3 – Pictures of 6500 Transmission Line

P36-P37 near Puna Rock

P192-P194 near Nanawale Estates

P196-197 near Nanawale Estates

P220-P229 near Nanawale Estates

P225 Near Nanawale Estates